STOPPING WATER POLLUTION AT ITS SOURCE

MISA

Municipal Industrial Strategy for Abatement

PRELIMINARY REPORT FOR THE FIRST SIX MONTHS OF MONITORING IN THE PETROLEUM REFINING SECTOR

(December 1, 1988 to May 31, 1989)

DECEMBER 1989

Environment Ontario

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Minister

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MUNICIPAL-INDUSTRIAL STRATEGY FOR ABATEMENT (MISA)

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Report prepared by:
Water Resources Branch

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I. BACKGROUND

The Petroleum Refining Sector Effluent Monitoring Regulation was promulgated in June 1988, as Ontario Regulation 359/88. The Regulation was amended in November 1988 to further clarify some monitoring requirements that specifically pertained to the Petroleum Sector. The amendments were filed as Ontario Regulation 696/88.

Except for an initial reporting requirement, which came into force September 1988, the Petroleum Sector Monitoring Regulation came into force December 1988.

In September 1988, seven petroleum refineries submitted their initial reports, identifying the sampling points and monitoring equipment in place to meet the requirements of the regulation. The information was confirmed by ministry staff through site visits in September and October 1988.

Throughout the fall of 1988, the ministry conducted a number of workshops for the ministry's regional staff and industry personnel. The purpose of these sessions was to ensure that all parties clearly understood the requirements imposed by the regulation. In addition, both regional and industrial staff were trained in use of the MISA Data Management System (MIDES). MIDES is designed to electronically handle monitoring data transfer from industry to ministry.

During the monitoring period data are collected by industry under strict protocols to ministry specifications. In addition to that, the companies are required to carry out a quality control program which will help validate the monitoring data. Besides flow monitoring and sampling for chemical analyses, the dischargers are also required to perform toxicity testing on their process effluents and once-through cooling water.

The ministry regional staff is keeping a close check on compliance with the regulation. They also inspect the plants during the monitoring period and carry out the audit sampling. The ministry's laboratory performs audit sample analyses to verify the analytical data collected by the industry. The ministry also performs two open scan characterizations on each refinery process effluent to check for potential new contaminants in the petroleum sector.

Both ministry and industry have been working very hard to implement the monitoring regulation and establish smooth flow of information.

The ministry is taking a statistical analysis approach for data interpretation and the proper evaluation of data can be done only at the end of the monitoring period when all the data are received.

II. PRESENT STATUS OF MONITORING

The Petroleum Sector is now in its twelfth month of effluent monitoring. Since data are reported 60 days (90 days for characterization) after the sample collection, the ministry has received about 9 months of data so far. As some

validations of data are pending, only the first 6 months of data were reviewed for this report.

1. QUANTITY OF ANALYTICAL DATA

A large amount of data has been collected in the first six months of monitoring. Following is the summary for all seven refineries - all data points in the petroleum sector - for the period December 1, 1988 to May 31, 1989:

Type of effluent	Number of data points
Process effluent	18,967
Once through cooling water	2,815
Storm Water	1,602
Landfarm Leachate	739
Emergency Overflow	17
Intake Water (optional-not required by regulation)	7,786
Quality Control	9,262
Total	41,188

2. PRELIMINARY ASSESSMENT OF THE FIRST SIX MONTHS OF MONITORING DATA

A preliminary review of data was done for the first six months of monitoring and several tables and figures are attached here.

The ministry is in the process of establishing policies regarding data interpretation. Pending these decisions, and in order to expedite the reporting of the petroleum sector data, certain assumptions were made for the purposes of this report only. For example, in the interpretation of the analytical results less than DL (laboratory method detection limit) the ministry could have used an arbitrary fraction of the Regulation MDL or laboratory MDL, such as 0.1, 0.3, or 1.0. In order to keep this first report as simple as possible the decision was made in this one instance to treat **all analytical results with remark codes "<DL", "<T" and "<W" as 0 (zero).** Naturally, this approach minimizes the apparent loadings for the refineries.

All analytical results with remark codes "<", ">", "A" or without a remark code are included.

All other data with the remark codes different than the ones above are ignored in this review (1.5% of the data), **because they represent questionable data.** (The list of remark codes is attached in the Appendix A.)

Quality control data are not considered in this review.

Loadings are calculated by multiplying reported flow by daily average concentration (arithmetic mean).

Any interpretations of the results reported at this stage can only be considered as of "interim" nature.

3. REVIEW OF MONITORING DATA FOR PROCESS EFFLUENT STREAMS

In this preliminary review the performance of the petroleum refining sector as a whole, as well as individual refineries performance, was examined. Only process effluent was considered in the review because it has the greatest environmental impact and it was extensively analyzed. All effluents will be analyzed in the final report.

Priority Pollutants and their frequency of occurrence

The total number of parameters identified in the first six months in the entire sector is 69 out of 149 parameters on the sector list. This covers all the analyses of process effluents including characterization. The parameters and their frequency of occurrence are shown in Table 1.

Tables 2.1 to 2.7 list the parameters identified in each of the refineries for all the frequencies of analyses. With the exception of Shell Canada all the refineries discharge their process effluent after the biotreater directly to the surface watercourses.

In the case of Shell Canada, process effluent from the biotreater is discharged either directly to Talford Creek or diverted to the Potentially Oily Water (POW) separator depending on the content of VSS (volatile suspended solids) in the biotreater effluent. If the process effluent contains more than 100 mg/L of VSS it is diverted to the POW separator for further settling of suspended solids. Evaluating the effect of settling is complicated by the fact that the process effluent becomes diluted with the large quantity of cooling water. In order to keep this first report simple the effect of additional settling of suspended solids was not taken in account. However, at the time of the final evaluation of the monitoring data actual loadings of suspended solids to the environment will be considered.

Dioxins and furans

Although dioxins and furans could be formed during some refining processes the first chemical characterization under MISA program identified only one of the dioxin compounds in one of the seven refineries.

The dioxin found is octachlorodibenzo-p-dioxin, the least toxic of the

dioxins, having approximately 0.0001 times toxicity of 2,3,7,8 TCDD. The concentration found was 0.65 ng/L (nanograms per litre) which translates into 0.065 parts per quadrillion (ppq) of 2,3,7,8 TCDD toxic equivalents. The MOE Interim Petroleum Effluent Guideline (December 1988) is 15 ppq of 2,3,7,8 TCDD toxic equivalents.

Routine Monitoring

The monthly average concentrations of selected **daily and thrice weekly** parameters for all seven refineries are shown on Figures 1.1 to 1.7.

Key to the Refinery numbers used in Figures is given in the Appendix B of this report.

Results compared to OEQE

All the individual results (not averages) were compared against the existing **Ontario Effluent Quality Objectives (OEQO)** for Petroleum Refineries (1977). The table below shows the number of refineries exceeding OEQO on any single day.

Parameter	OEQO	Refineries exceeding
Oil and Grease	10 mg/L	four
Phenols	20 ug/L	five
Suspended Solids	15 mg/L	seven
Ammonia	10 mg/L	five
pH	5.5-9.5	none
Chromium	1 mg/L	none
Zinc	1 mg/L	three

Quarterly and characterization analyses identified metals, such as copper, nickel and lead in concentrations far below OEQO for petroleum refineries.

Flow data

Table 3.0 and Figure 2.0 show monthly average flow data for process effluent.

Loadings

Loadings for daily and thrice weekly parameters are listed in Table 4.0. Figures 3.1 to 3.7 show loadings for some daily and thrice weekly parameters.

Toxicity Testing

Of the more than 50 samples that were tested, only the process effluent of one refinery caused mortalities. Three out of six samples were lethal to tested species and only one of the three samples was lethal to both Daphnia and trout. Ministry's scientists have done a preliminary investigation of the causes of mortality. By correlating toxicity data with the chemical analysis results, they have been able to identify that the high concentration of zinc (27 mg/L) present in the effluent at the time of sampling caused mortality of both species. Other contributors may have been hexavalent chromium and ammonia. Further investigation will be carried out to assess the potential impact of trace contaminants found in the chemical characterization of this refinery process effluent.

The results of toxicity tests for all refineries are summarized below:

	Lethality	
Refinery	**Rainbow trout**	**Daphnia Magna**
Esso Petroleum (Sarnia)	none	none
Petro-Canada (Mississauga)	none	none
Petro-Canada (Oakville)	2 of 6	2 of 6
Petrosar Limited (Sarnia)	none	none
Shell Canada (Sarnia)	none	none
Suncor Inc. (Sarnia)	none	none
McColl-Frontenac (Nanticoke)	none	none

III STATUS OF THE PETROLEUM REFINING SECTOR

All seven Ontario refineries presently employ some kind of waste water treatment for their effluents. A typical refinery waste water treatment system consists of sour water stripping (removal of ammonia and sulphides), sewer segregation, oil separation, biological oxidation of organic contaminants and clarification (removal of suspended solids). The level of sophistication varies among the refineries. Some refineries also have equalization ponds, enhanced oil removal through air floatation, dual media filters and carbon filters. All seven refineries have storm water collection and controlled discharge of storm water.

In the period of 1963-1988 the Ontario Petroleum refineries have spent about $300 million to install advanced waste water treatment facilities. Due to technology changes over 15 years and in anticipation of the upcoming MISA effluent limits regulations, Ontario Petroleum refineries have committed an additional $40 million in the last two years to improve their waste water treatment operations. These improvements cover treatment facilities expansions as well as equipment changes. In some cases the sector is also trying to achieve contaminants reduction through process change or substitution of chemicals. For example one refinery recently switched from zinc-chromium based additives to a phosphate based additive for their cooling water treatment program. As a result the chromium levels in the final effluent have fallen below MISA detection limits.

In 1988, during the preparation for the MISA monitoring, dioxins and furans were identified for the first time in the petroleum refining sector. The source was an internal stream - effluent from the catalyst regeneration process. An extensive survey was carried out on all Ontario refineries to determine the extent of their potential problem. This discovery caused considerable concern for both ministry and industry and actions were taken including containment, chemical treatment, and research involving both treatment technologies and process changes to eliminate formation of these dioxins and furans.

IV CONCLUSIONS

The amount and quality of analytical data collected over the first six months of monitoring indicate that a good data base will be established for the petroleum refining sector at the end of the monitoring period. This data base appears to be satisfactory for use in setting the effluent limits.

Preliminary analyses of data shows that the performance of the refineries is about as expected regarding effluent quality. However, in one of seven refineries toxicity tests resulted in lethality of the tested species (three out of six samples). One out of six process effluent samples was lethal to both rainbow trout and Daphnia Magna. The preliminary investigation of the cause of lethality points towards operating procedures in handling certain chemical additives.

The first six months of monitoring data show that the newer refineries have lower loadings of contaminants in their effluents than the older refineries. Again, this is not surprising, since newer equipment, reduced water use, better operating practices and improved environmental considerations taken during the design of the refinery should improve effluent quality.

The older refineries are aware of these facts and have committed additional funds to improve the quality of their effluents, and several improvement projects are currently underway, well before the effluent limit regulations are imposed.

Looking at the Petroleum Refining sector as a whole there is still room for improvement in waste water treatment, through updating the equipment, process changes and improving operating practices. Chemical spills continue to be a problem for the sector. Together with the limits regulations the MISA program will emphasize the application of Best Management Practices (BMPs). These practices will specify actions and activities that reduce the likelihood of spills of toxic pollutants or hazardous substances.

TABLE 1.0
PRIORITY POLLUTANTS FOUND IN PROCESS EFFLUENT
(ALL 7 REFINERIES)

PARAMETER	N.	F.O.	MIN	MAX	AVG	UNIT
COD	48	100	10.000	269.000	53.250	mg/L
DOC	612	100	.000	79.000	13.191	mg/L
Hydrogen ion (pH)	1294	100	6.200	9.000	7.627	
Specific conductance	48	100	442.000	2,680.000	1,416.104	uS/cm
TOC	513	100	2.000	100.000	18.991	mg/L
Total Kjeldahl nitrogen	39	100	.370	19.500	2.817	mg/L
Total suspended solids	768	99	.000	1,038.000	29.777	mg/L
VSS	1263	98	.000	666.000	14.787	mg/L
Zinc	345	95	.000	31,200.000	752.664	ug/L
Aluminum	48	94	.000	2,200.000	336.272	ug/L
Arsenic	48	94	.000	38.000	8.542	ug/L
Phenolics (4AAP)	1320	94	.000	296.000	13.784	ug/L
Nitrate+Nitrite	41	93	.000	5.690	1.837	mg/L
Cyanide Total	45	84	.000	.085	.012	mg/L
Chromium	346	83	.000	690.000	125.943	ug/L
Chromium (hexavalent)	6	83	.000	31.000	18.833	ug/L
Total phosphorus	580	83	.000	34.800	.450	mg/L
Oil and grease	611	82	.000	16.800	2.545	mg/L
Ammonia plus Ammonium	614	79	.000	23.100	1.566	mg/L
Sulphide	744	72	.000	.600	.103	mg/L
Selenium	48	58	.000	23.000	4.165	ug/L
Chloroform	53	43	.000	5.600	.511	ug/L
Copper	48	38	.000	30.000	4.021	ug/L
Molybdenum	48	35	.000	116.000	15.583	ug/L
Nickel	48	33	.000	29.000	3.188	ug/L
Methylene chloride	53	28	.000	13.550	1.071	ug/L
Bis(2-ethyhexyl) phthalate	22	27	.000	11.000	.900	ug/L
Antimony	48	25	.000	14.000	.488	ug/L
Cobalt	48	25	.000	75.000	3.667	ug/L
Di-n-butyl phthalate	22	23	.000	2.200	.300	ug/L
Benzene	585	21	.000	82.223	.661	ug/L
Vanadium	48	21	.000	20.000	2.542	ug/L
Mercury	48	19	.000	.150	.019	ug/L
Toluene	585	19	.000	33.800	.590	ug/L
o-Xylene	585	18	.000	101.900	1.348	ug/L
1,2-Dichloropropane	53	17	.000	3.900	.497	ug/L
m-Xylene and p-Xylene	585	16	.000	62.200	.775	ug/L
Styrene	53	15	.000	1.443	.143	ug/L
Anthracene	48	13	.000	.540	.040	ug/L
Chloromethane	53	13	.000	13.800	1.593	ug/L
Phenol	48	13	.000	9.560	.441	ug/L

N. = NUMBER OF ANALYSIS
F.O. = FREQUENCY OF DETECTION ABOVE THE LABORATORY METHOD DETECTION LIMIT
MIN = MINIMUM CONCENTRATION
MAX = MAXIMUM CONCENTRATION
AVG = AVERAGE CONCENTRATION IN 6 MONTHS
UNIT = UNIT OF MEASUREMENT

TABLE 1.0(CONTINUED)
PRIORITY POLLUTANTS FOUND IN PROCESS EFFLUENT
(ALL 7 REFINERIES)

PARAMETER	N.	F.O.	MIN	MAX	AVG	UNIT
Thallium	48	13	.000	310.000	19.354	ug/L
1,2,3,4-Tetrachlorobenzene	10	10	.000	.200	.020	ug/L
2,4,5-Trichlorotoluene	10	10	.000	.010	.001	ug/L
Chrysene	48	10	.000	.430	.042	ug/L
PCBT	10	10	.000	5,200.000	520.000	ng/L
Silver	48	10	.000	3.000	.271	ug/L
2-Methylnaphthalene	48	8	.000	42.500	.922	ug/L
Benz(a)anthracene	48	8	.000	.290	.022	ug/L
Ethylbenzene	585	8	.000	24.300	.149	ug/L
Lead	48	8	.000	230.000	5.375	ug/L
Octachlorodibenzo-p-dioxin	12	8	.000	.650	.054	ng/L
1,2-Dichloroethane	53	6	.000	.400	.019	ug/L
Benzo(b)fluoranthene	48	6	.000	2.600	.071	ug/L
Pyrene	48	6	.000	.340	.019	ug/L
o-Cresol	48	6	.000	2.350	.105	ug/L
Acenaphthene	48	4	.000	4.000	.088	ug/L
Cadmium	48	4	.000	9.000	.192	ug/L
Phenanthrene	48	4	.000	2.830	.066	ug/L
m-Cresol	48	4	.000	1.000	.035	ug/L
p-Cresol	45	4	.000	1.900	.084	ug/L
1-Methylnaphthalene	48	2	.000	1.530	.032	ug/L
2,4-Dimethylphenol	48	2	.000	.580	.012	ug/L
4-Chloro-3-methylphenol	48	2	.000	4.220	.088	ug/L
4-Nitrophenol	48	2	.000	2.400	.050	ug/L
Acenaphthylene	48	2	.000	.800	.017	ug/L
Dibromochloromethane	53	2	.000	1.010	.019	ug/L
Fluorene	48	2	.000	4.420	.092	ug/L
Naphthalene	48	2	.000	1.280	.027	ug/L

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UNIT = UNIT OF MEASUREMENT

TABLE 2.1
PRIORITY POLLUTANTS FOUND IN PROCESS EFFLUENT
ESSO PETROLEUM CANADA

PARAMETER	N.	F.O.	MIN	MAX	AVG	UNIT
Arsenic	8	100	2.000	10.000	7.000	ug/L
COD	8	100	28.000	39.000	34.500	mg/L
Cyanide Total	8	100	.005	.085	.020	mg/L
Hydrogen ion (pH)	184	100	7.000	8.400	7.523	
Nitrate+Nitrite	8	100	3.690	5.690	4.754	mg/L
Selenium	8	100	12.000	23.000	16.500	ug/L
Specific conductance	8	100	654.000	916.000	777.125	uS/cm
TOC	83	100	4.000	88.000	15.902	mg/L
Total Kjeldahl nitrogen	6	100	.900	1.200	.983	mg/L
Total suspended solids	75	100	2.400	54.000	13.996	mg/L
Zinc	8	100	.020	42.000	21.878	ug/L
DOC	83	99	.000	17.000	9.901	mg/L
VSS	164	98	.000	56.700	11.654	mg/L
Phenolics (4AAP)	184	96	.000	11.000	3.533	ug/L
Total phosphorus	80	94	.000	34.800	1.221	mg/L
Ammonia plus Ammonium	83	92	.000	11.000	.642	mg/L
Aluminum	8	88	.000	384.000	150.005	ug/L
Sulphide	84	83	.000	.220	.034	mg/L
Toluene	81	69	.000	17.100	2.083	ug/L
Methylene chloride	9	67	.000	1.900	.667	ug/L
o-Xylene	81	54	.000	29.700	1.669	ug/L
m-Xylene and p-Xylene	81	53	.000	55.300	2.694	ug/L
Benzene	81	52	.000	21.900	1.588	ug/L
Chloroform	9	44	.000	.500	.178	ug/L
1,2-Dichloroethane	9	33	.000	.400	.111	ug/L
Oil and grease	84	32	.000	9.700	.700	mg/L
Copper	8	25	.000	14.000	3.500	ug/L
Ethylbenzene	81	22	.000	24.300	.648	ug/L
Phenol	8	13	.000	3.300	.413	ug/L

N. = NUMBER OF ANALYSIS
F.O. = FREQUENCY OF DETECTION ABOVE THE LABORATORY METHOD DETECTION LIMIT
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MAX = MAXIMUM CONCENTRATION
AVG = AVERAGE CONCENTRATION IN 6 MONTHS
UNIT = UNIT OF MEASUREMENT

TABLE 2.2
PRIORITY POLLUTANTS FOUND IN PROCESS EFFLUENT
PETRO-CANADA INC; LAKE ONTARIO REFINERY - MISSISSAUGA PLANT

PARAMETER	N.	F.O.	MIN	MAX	AVG	UNIT
Aluminum	6	100	65.000	347.000	217.000	ug/L
Antimony	6	100	1.100	1.200	1.117	ug/L
Arsenic	6	100	3.300	7.500	5.050	ug/L
COD	6	100	20.000	43.000	30.333	mg/L
DOC	102	100	4.000	46.500	10.796	mg/L
Hydrogen ion (pH)	182	100	6.700	7.900	7.408	
Molybdenum	6	100	5.000	110.000	54.167	ug/L
Nickel	6	100	3.000	10.000	6.167	ug/L
Nitrate+Nitrite	6	100	.366	.731	.485	mg/L
Specific conductance	6	100	608.000	789.000	673.333	uS/cm
TOC	90	100	5.000	56.000	16.606	mg/L
Total Kjeldahl nitrogen	6	100	.600	3.320	1.603	mg/L
Total suspended solids	102	100	5.100	551.200	24.627	mg/L
VSS	179	100	1.100	391.200	15.445	mg/L
Chromium	80	98	.000	550.000	112.700	ug/L
Ammonia plus Ammonium	77	95	.000	22.500	1.606	mg/L
Oil and grease	78	95	.000	13.700	3.741	mg/L
Zinc	79	95	.000	1,270.000	81.949	ug/L
Phenolics (4AAP)	210	90	.000	62.600	8.139	ug/L
Sulphide	119	89	.000	.199	.046	mg/L
Vanadium	6	83	.000	20.000	13.833	ug/L
Copper	6	67	.000	8.000	4.833	ug/L
Thallium	6	67	.000	310.000	148.167	ug/L
Chloroform	7	57	.000	2.910	.909	ug/L
Cobalt	6	50	.000	5.000	2.000	ug/L
Lead	6	50	.000	230.000	42.333	ug/L
Mercury	6	50	.000	.100	.050	ug/L
Selenium	6	50	.000	2.500	1.117	ug/L
Cyanide Total	6	33	.000	.010	.002	mg/L
Silver	6	33	.000	3.000	.833	ug/L
Total phosphorus	90	31	.000	3.100	.099	mg/L
Styrene	7	29	.000	1.443	.290	ug/L
Cadmium	6	17	.000	9.000	1.500	ug/L
Benzene	79	15	.000	.920	.043	ug/L
Dibromochloromethane	7	14	.000	1.010	.144	ug/L
Methylene chloride	7	14	.000	13.550	1.936	ug/L
m-Xylene and p-Xylene	79	11	.000	.750	.029	ug/L
o-Xylene	79	8	.000	1.340	.038	ug/L
Ethylbenzene	79	1	.000	.200	.003	ug/L
Toluene	79	1	.000	.130	.002	ug/L

N. = NUMBER OF ANALYSIS
F.O. = FREQUENCY OF DETECTION ABOVE THE LABORATORY METHOD DETECTION LIMIT
MIN = MINIMUM CONCENTRATION
MAX = MAXIMUM CONCENTRATION
AVG = AVERAGE CONCENTRATION IN 6 MONTHS
UNIT = UNIT OF MEASUREMENT

TABLE 2.3
PRIORITY POLLUTANTS FOUND IN PROCESS EFFLUENT
PETRO-CANADA INC; LAKE ONTARIO REFINERY - OAKVILLE PLANT

PARAMETER	N.	F.O.	MIN	MAX	AVG	UNIT
1,2,3,4-Tetrachlorobenzene	1	100	.200	.200	.200	ug/L
1,2-Dichloropropane	9	100	1.340	3.900	2.929	ug/L
2,4,5-Trichlorotoluene	1	100	.010	.010	.010	ug/L
Ammonia plus Ammonium	79	100	1.100	23.100	5.799	mg/L
Anthracene	6	100	.110	.540	.318	ug/L
Arsenic	6	100	5.000	27.000	11.950	ug/L
COD	6	100	69.000	269.000	122.667	mg/L
Chromium	79	100	.040	690.000	76.345	ug/L
DOC	104	100	10.500	72.000	20.544	mg/L
Hydrogen ion (pH)	197	100	7.200	9.000	8.102	
Molybdenum	6	100	12.000	116.000	43.833	ug/L
Nickel	6	100	3.000	9.000	6.333	ug/L
Nitrate+Nitrite	6	100	.127	.343	.218	mg/L
Octachlorodibenzo-p-dioxin	1	100	.650	.650	.650	ng/L
PCBT	1	100	5,200.000	5,200.000	5,200.000	ng/L
Phenolics (4AAP)	197	100	12.000	296.000	55.447	ug/L
Specific conductance	6	100	1,690.000	2,260.000	1,956.667	uS/cm
Sulphide	92	100	.070	.390	.172	mg/L
TOC	92	100	13.000	100.000	27.054	mg/L
Total Kjeldahl nitrogen	6	100	2.700	19.500	8.040	mg/L
Total suspended solids	82	100	5.000	65.000	17.988	mg/L
VSS	197	100	4.000	32.000	11.655	mg/L
Zinc	79	100	.003	31,200.000	2,535.105	ug/L
Oil and grease	78	99	.000	16.800	2.058	mg/L
Total phosphorus	92	97	.000	3.680	.657	mg/L
Antimony	6	83	.000	.600	.450	ug/L
Cyanide Total	6	83	.000	.009	.007	mg/L
Chloromethane	9	78	.000	13.800	9.380	ug/L
Aluminum	6	67	.000	330.000	126.500	ug/L
Selenium	6	67	.000	9.100	3.367	ug/L
Styrene	9	67	.000	1.260	.613	ug/L
2-Methylnaphthalene	6	50	.000	42.500	7.360	ug/L
Cobalt	6	50	.000	75.000	17.500	ug/L
Phenol	6	50	.000	9.560	2.950	ug/L
Pyrene	6	50	.000	.340	.155	ug/L
Silver	6	50	.000	3.000	1.333	ug/L
o-Cresol	6	50	.000	2.350	.836	ug/L
o-Xylene	81	42	.000	101.900	7.298	ug/L
Acenaphthene	6	33	.000	4.000	.703	ug/L
m-Cresol	6	33	.000	1.000	.283	ug/L
p-Cresol	6	33	.000	1.900	.633	ug/L

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MIN = MINIMUM CONCENTRATION
MAX = MAXIMUM CONCENTRATION
AVG = AVERAGE CONCENTRATION IN 6 MONTHS
UNIT = UNIT OF MEASUREMENT

TABLE 2.3 (CONTINUED)
PRIORITY POLLUTANTS FOUND IN PROCESS EFFLUENT
PETRO-CANADA INC; LAKE ONTARIO REFINERY - OAKVILLE PLANT

PARAMETER	N.	F.O.	MIN	MAX	AVG	UNIT
Benzene	81	32	.000	38.980	.838	ug/L
m-Xylene and p-Xylene	81	23	.000	62.200	1.684	ug/L
1-Methylnaphthalene	6	17	.000	1.530	.255	ug/L
2,4-Dimethylphenol	6	17	.000	.580	.097	ug/L
4-Chloro-3-methylphenol	6	17	.000	4.220	.703	ug/L
4-Nitrophenol	6	17	.000	2.400	.400	ug/L
Acenaphthylene	6	17	.000	.800	.133	ug/L
Fluorene	6	17	.000	4.420	.737	ug/L
Naphthalene	6	17	.000	1.280	.213	ug/L
Phenanthrene	6	17	.000	2.830	.472	ug/L
Toluene	81	9	.000	33.800	.555	ug/L
Ethylbenzene	81	1	.000	1.590	.020	ug/L

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MIN = MINIMUM CONCENTRATION
MAX = MAXIMUM CONCENTRATION
AVG = AVERAGE CONCENTRATION IN 6 MONTHS
UNIT = UNIT OF MEASUREMENT

TABLE 2.4
PRIORITY POLLUTANTS FOUND IN PROCESS EFFLUENT
PETROSAR LIMITED

PARAMETER	N.	F.O.	MIN	MAX	AVG	UNIT
Aluminum	9	100	260.000	370.000	302.222	ug/L
Arsenic	9	100	6.000	38.000	15.111	ug/L
COD	9	100	52.000	99.000	73.667	mg/L
Chromium	83	100	120.000	550.000	318.675	ug/L
Cyanide Total	9	100	.006	.014	.010	mg/L
DOC	82	100	5.000	79.000	19.566	mg/L
Hydrogen ion (pH)	185	100	6.930	8.700	7.802	
Nitrate+Nitrite	9	100	2.000	2.700	2.333	mg/L
Specific conductance	9	100	2,280.000	2,680.000	2,476.667	uS/cm
TOC	82	100	7.000	83.000	23.354	mg/L
Total Kjeldahl nitrogen	9	100	1.900	3.600	2.611	mg/L
Total phosphorus	82	100	.040	.630	.203	mg/L
Total suspended solids	85	100	8.000	34.000	17.482	mg/L
VSS	183	100	3.000	25.000	8.814	mg/L
Zinc	83	100	180.000	1,010.000	596.627	ug/L
Phenolics (4AAP)	181	98	.000	33.000	6.956	ug/L
Ammonia plus Ammonium	82	94	.000	1.300	.482	mg/L
Sulphide	162	94	.000	.560	.298	mg/L
Chloroform	9	89	.000	1.300	.924	ug/L
Oil and grease	82	62	.000	15.000	2.902	mg/L
Bis(2-ethyhexyl) phthalate	9	56	.000	2.400	.978	ug/L
Benz(a)anthracene	9	44	.000	.290	.116	ug/L
Chrysene	9	44	.000	.430	.178	ug/L
Di-n-butyl phthalate	9	44	.000	1.100	.489	ug/L
Copper	9	33	.000	30.000	7.778	ug/L
Methylene chloride	9	33	.000	3.200	.822	ug/L
Benzo(b)fluoranthene	9	22	.000	.400	.089	ug/L
Nickel	9	22	.000	29.000	6.444	ug/L

N. = NUMBER OF ANALYSIS
F.O. = FREQUENCY OF DETECTION ABOVE THE LABORATORY METHOD DETECTION LIMIT
MIN = MINIMUM CONCENTRATION
MAX = MAXIMUM CONCENTRATION
AVG = AVERAGE CONCENTRATION IN 6 MONTHS
UNIT = UNIT OF MEASUREMENT

TABLE 2.5
PRIORITY POLLUTANTS FOUND IN PROCESS EFFLUENT
SHELL CANADA PRODUCTS LIMITED

PARAMETER	N.	F.O.	MIN	MAX	AVG	UNIT
Aluminum	6	100	780.000	2,200.000	1,408.333	ug/L
COD	6	100	20.000	110.000	58.333	mg/L
Cobalt	6	100	4.000	21.000	9.833	ug/L
Cyanide Total	6	100	.007	.016	.012	mg/L
DOC	80	100	3.000	42.000	14.914	mg/L
Hydrogen ion (pH)	182	100	6.500	8.500	7.642	
Specific conductance	6	100	442.000	780.000	598.833	uS/cm
TOC	81	100	4.000	61.000	20.659	mg/L
Total Kjeldahl nitrogen	6	100	.370	4.900	2.412	mg/L
Oil and grease	132	98	.000	15.000	4.255	mg/L
Phenolics (4AAP)	180	98	.000	26.000	6.548	ug/L
Total suspended solids	180	96	.000	1,038.000	81.183	mg/L
VSS	180	92	.000	666.000	47.506	mg/L
Zinc	83	84	.000	130.000	32.069	ug/L
Total phosphorus	81	83	.000	3.230	.530	mg/L
Vanadium	6	83	.000	11.000	6.500	ug/L
Copper	6	67	.000	6.000	3.500	ug/L
Chromium	83	55	.000	150.000	25.048	ug/L
Arsenic	6	50	.000	13.000	4.167	ug/L
Nitrate+Nitrite	6	50	.000	.060	.025	mg/L
Toluene	83	34	.000	24.798	1.156	ug/L
Ammonia plus Ammonium	132	25	.000	16.900	.428	mg/L
Benzene	83	25	.000	82.223	2.027	ug/L
m-Xylene and p-Xylene	83	18	.000	42.860	1.015	ug/L
Antimony	6	17	.000	14.000	2.333	ug/L
Benzo(b)fluoranthene	6	17	.000	2.600	.433	ug/L
Nickel	6	17	.000	10.000	1.667	ug/L
Phenanthrene	6	17	.000	.350	.058	ug/L
Ethylbenzene	83	14	.000	8.970	.289	ug/L
o-Xylene	83	12	.000	16.800	.485	ug/L
Sulphide	131	5	.000	.600	.006	mg/L

N. = NUMBER OF ANALYSIS
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MIN = MINIMUM CONCENTRATION
MAX = MAXIMUM CONCENTRATION
AVG = AVERAGE CONCENTRATION IN 6 MONTHS
UNIT = UNIT OF MEASUREMENT

TABLE 2.6
PRIORITY POLLUTANTS FOUND IN PROCESS EFFLUENT
SUNCOR INC.

PARAMETER	N.	F.O.	MIN	MAX	AVG	UNIT
Aluminum	7	100	30.000	300.000	132.857	ug/L
Arsenic	7	100	2.000	6.000	3.714	ug/L
COD	7	100	10.000	27.000	20.857	mg/L
Cyanide Total	7	100	.011	.060	.027	mg/L
DOC	77	100	2.000	78.000	8.444	mg/L
Hydrogen ion (pH)	182	100	6.200	7.900	7.085	
Selenium	7	100	1.000	6.000	2.571	ug/L
Specific conductance	7	100	444.000	1,420.000	1,226.143	uS/cm
TOC	80	100	2.000	88.000	10.260	mg/L
Total suspended solids	163	100	2.000	18.000	7.117	mg/L
Zinc	7	100	30.000	110.000	57.143	ug/L
Oil and grease	78	99	.000	6.000	1.261	mg/L
VSS	180	99	.000	13.000	4.167	mg/L
Ammonia plus Ammonium	82	98	.000	20.000	2.626	mg/L
Phenolics (4AAP)	182	98	.000	120.000	9.538	ug/L
Total phosphorus	76	96	.000	1.050	.196	mg/L
Sulphide	77	69	.000	.080	.014	mg/L
Chloroform	7	57	.000	.900	.414	ug/L
Copper	7	43	.000	10.000	4.286	ug/L
Methylene chloride	7	29	.000	5.400	1.186	ug/L
Chrysene	7	14	.000	.400	.057	ug/L
Nickel	7	14	.000	10.000	1.429	ug/L
Toluene	85	13	.000	15.200	.380	ug/L
m-Xylene and p-Xylene	85	7	.000	4.300	.139	ug/L
Ethylbenzene	85	6	.000	4.900	.102	ug/L
o-Xylene	85	6	.000	5.900	.216	ug/L
Benzene	85	5	.000	11.300	.156	ug/L

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MAX = MAXIMUM CONCENTRATION
AVG = AVERAGE CONCENTRATION IN 6 MONTHS
UNIT = UNIT OF MEASUREMENT

TABLE 2.7
PRIORITY POLLUTANTS FOUND IN PROCESS EFFLUENT
McCOLL-FRONTENAC INC.

PARAMETER	N.	F.O.	MIN	MAX	AVG	UNIT
Aluminum	6	100	20.000	240.000	130.000	ug/L
Arsenic	6	100	5.000	17.000	10.833	ug/L
COD	6	100	11.000	57.000	33.833	mg/L
DOC	84	100	2.100	21.000	6.732	mg/L
Hydrogen ion (pH)	182	100	6.800	8.300	7.789	
Mercury	6	100	.050	.150	.100	ug/L
Nitrate+Nitrite	6	100	.870	4.410	1.990	mg/L
Selenium	6	100	3.000	6.000	3.833	ug/L
Specific conductance	6	100	1,620.000	2,200.000	1,918.333	uS/cm
TOC	5	100	4.800	7.800	5.960	mg/L
Total Kjeldahl nitrogen	6	100	1.090	1.630	1.355	mg/L
Zinc	6	100	20.000	40.000	27.500	ug/L
Total suspended solids	81	99	.000	19.000	7.079	mg/L
VSS	180	98	.000	12.800	4.386	mg/L
Ammonia plus Ammonium	79	86	.000	2.700	.196	mg/L
Total phosphorus	79	86	.000	1.300	.244	mg/L
Oil and grease	79	84	.000	6.500	1.846	mg/L
Chromium (hexavalent)	6	83	.000	31.000	18.833	ug/L
Molybdenum	6	83	.000	40.000	26.667	ug/L
Phenolics (4AAP)	186	77	.000	20.000	3.973	ug/L
Sulphide	79	68	.000	.300	.035	mg/L
Chloroform	6	50	.000	5.600	1.313	ug/L
Methylene chloride	6	50	.000	13.000	3.583	ug/L
Bis(2-ethyhexyl) phthalate	3	33	.000	11.000	3.667	ug/L
Copper	6	33	.000	10.000	2.500	ug/L
Cyanide Total	3	33	.000	.003	.001	mg/L
Di-n-butyl phthalate	3	33	.000	2.200	.733	ug/L
Phenol	6	33	.000	.100	.030	ug/L
Thallium	6	33	.000	20.000	6.667	ug/L
Benzene	83	22	.000	1.200	.066	ug/L
2-Methylnaphthalene	6	17	.000	.100	.017	ug/L
Cadmium	6	17	.000	.200	.033	ug/L
Lead	6	17	.000	4.000	.667	ug/L
Ethylbenzene	83	13	.000	.160	.006	ug/L
Toluene	83	13	.000	.500	.034	ug/L
o-Xylene	83	10	.000	.390	.008	ug/L
m-Xylene and p-Xylene	83	2	.000	.200	.003	ug/L

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UNIT = UNIT OF MEASUREMENT

TABLE 3
PROCESS EFFLUENT
MONTHLY AVERAGE FLOW (M3/DAY) FOR 7 REFINERIES

REFINERY	DEC	JAN	FEB	MAR	APR	MAY
1	26,272	26,295	25,239	22,027	24,295	33,388
2	9,166	8,959	8,519	9,602	10,966	8,584
3	3,488	4,635	4,579	4,261	4,626	5,193
4	4,948	5,630	5,363	6,354	6,866	5,206
5	11,094	10,981	11,496	12,136	12,223	13,568
6	9,276	9,185	8,175	8,836	9,450	8,678
7	5,248	6,203	7,043	6,026	7,942	7,719

TABLE 4.0
AVERAGE DAILY LOADING (kg/day) IN 6 MONTHS
FOR DAILY AND THRICE WEEKLY PARAMETERS
(ALL 7 REFINERIES)

PARAMETER	1	2	3	4	5	6	7
Ammonia plus Ammonium	16.58	15.50	24.12	2.68	4.68	23.23	1.30
Benzene	.05	.00	.00	.00	.02	.00	.00
Chromium	.00	1.11	.35	1.85	.30	.00	.00
DOC	260.99	105.35	97.97	110.38	178.24	73.66	45.13
Ethylbenzene	.02	.00	.00	.00	.00	.00	.00
Oil and grease	17.15	34.92	8.71	15.08	48.46	11.53	12.04
Phenolics (4AAP)	.09	.06	.23	.04	.07	.09	.03
Sulphide	.90	.42	.81	1.71	.10	.13	.23
TOC	396.19	157.52	128.86	129.88	237.38	87.76	41.14
Toluene	.05	.00	.00	.00	.01	.00	.00
Total phosphorus	30.08	.96	3.17	1.06	6.38	1.77	1.47
Total suspended solids	338.81	108.41	82.95	102.49	320.71	63.46	47.89
VSS	288.74	88.71	52.16	49.68	255.47	36.76	30.38
Zinc	.47	.84	10.48	3.40	.36	.53	.19
m-Xylene and p-Xylene	.07	.00	.00	.00	.	.00	.00
o-Xylene	.04	.00	.02	.00	.	.00	.00

FIGURE 1.1

Monthly Average Concentration of Benzene (ug/L)

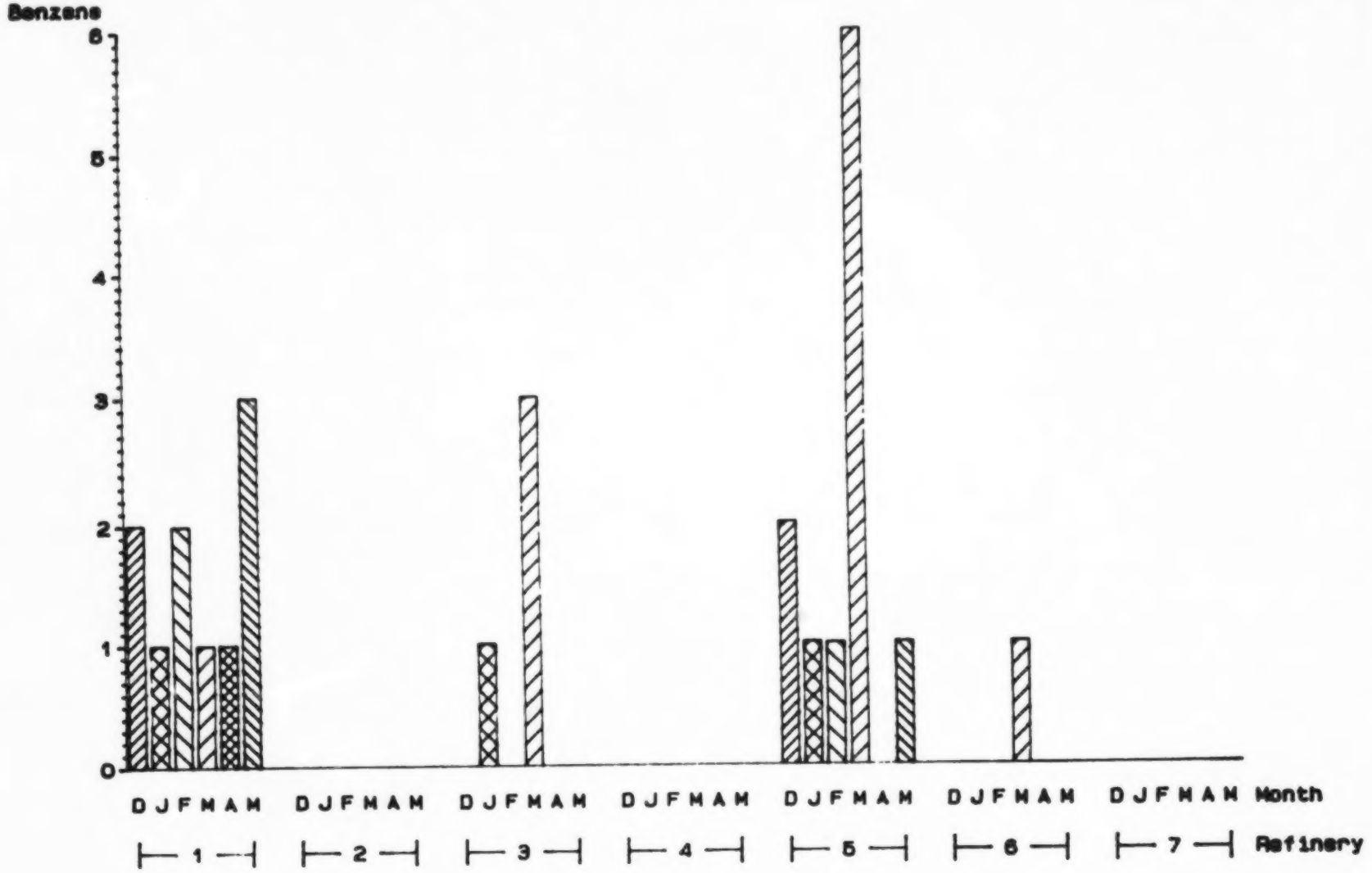


FIGURE 1.2

Monthly Average Concentration of Chromium (ug/L)

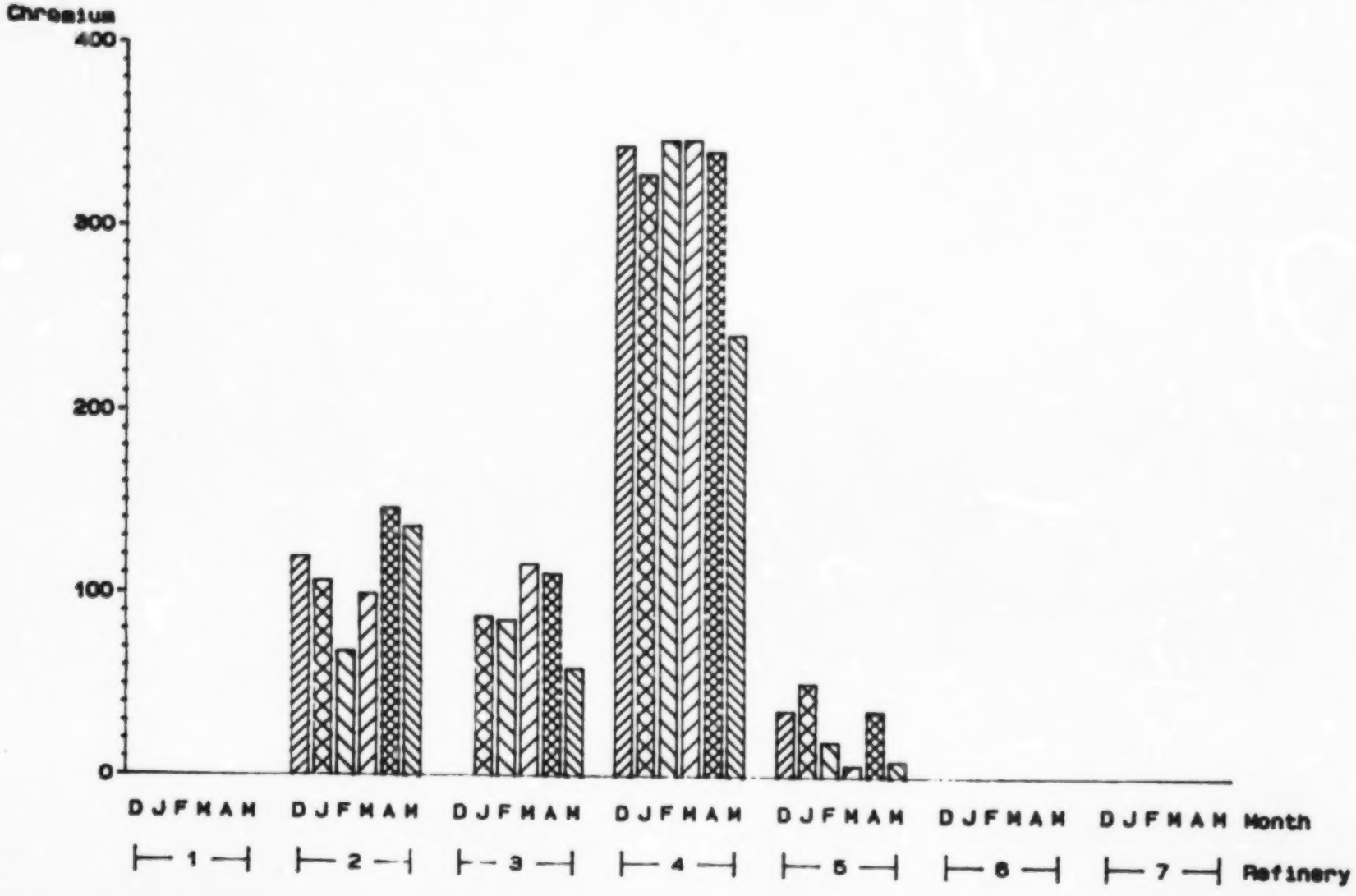


FIGURE 1.3

Monthly Average Concentration of Oil & Grease (mg/L)

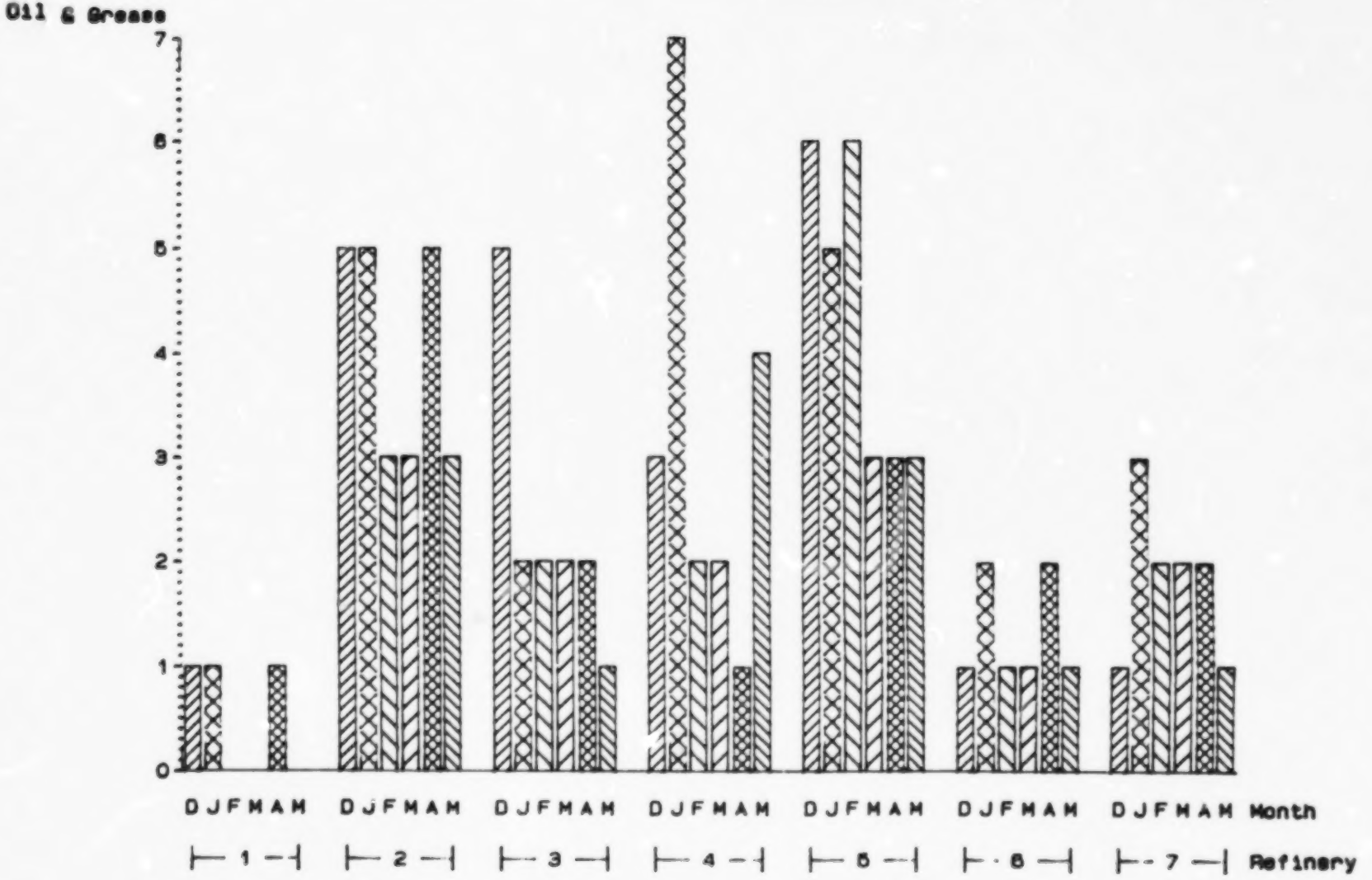


FIGURE 1.4

Monthly Average Concentration of Phenolics – 4AAP (ug/L)

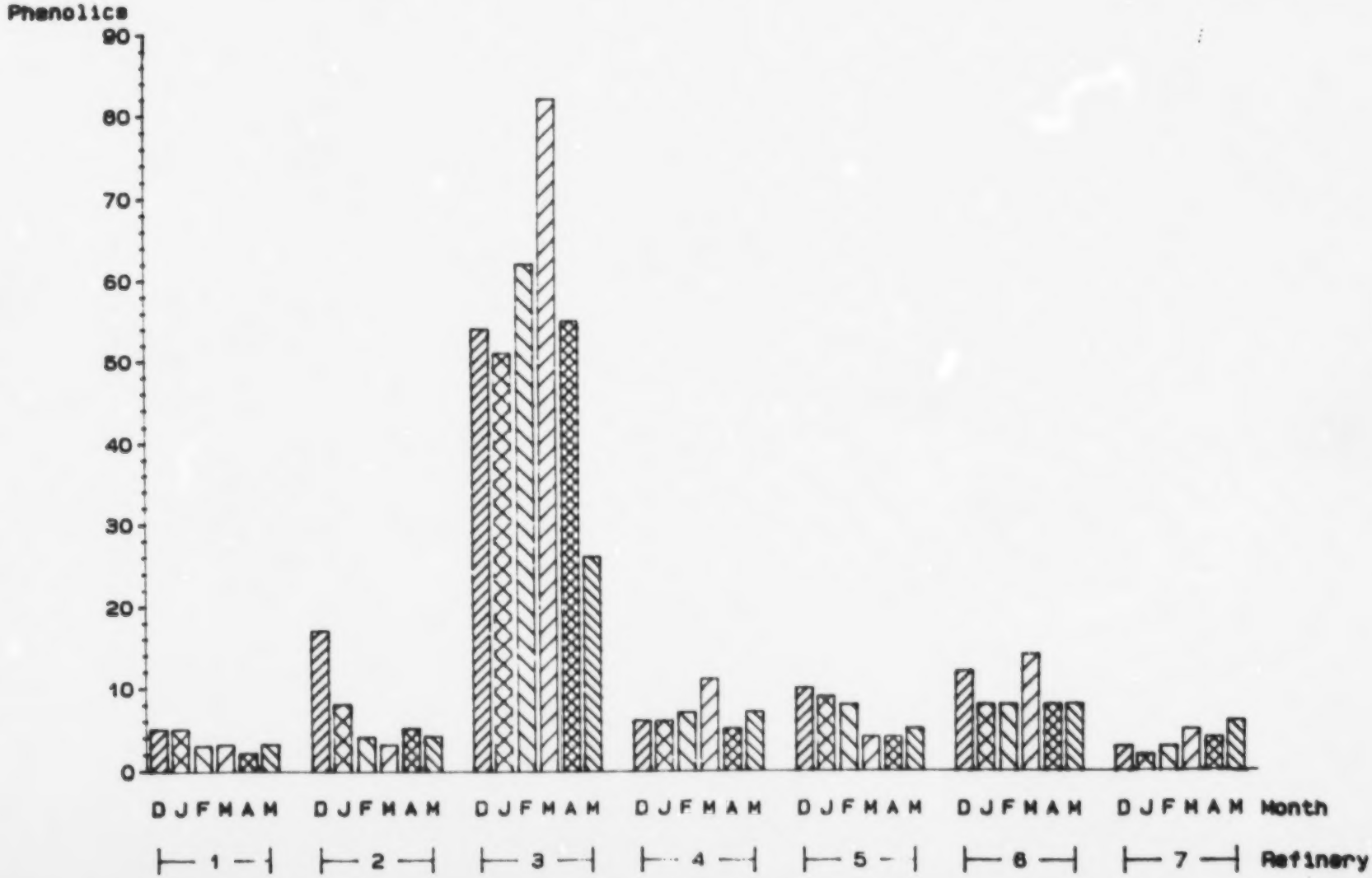


FIGURE 1.5

Monthly Average Concentration of Sulphide (mg/L)

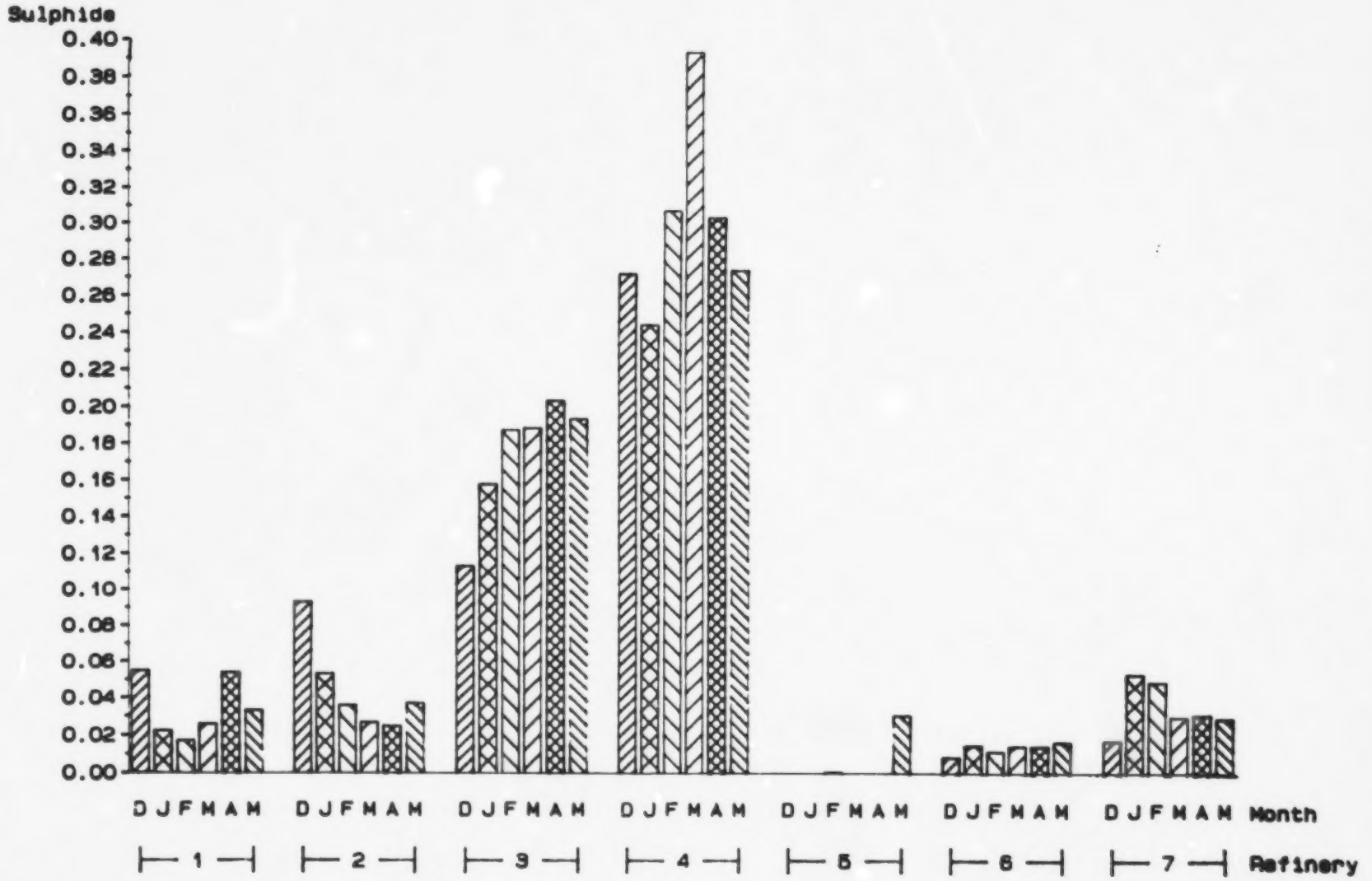


FIGURE 1.6

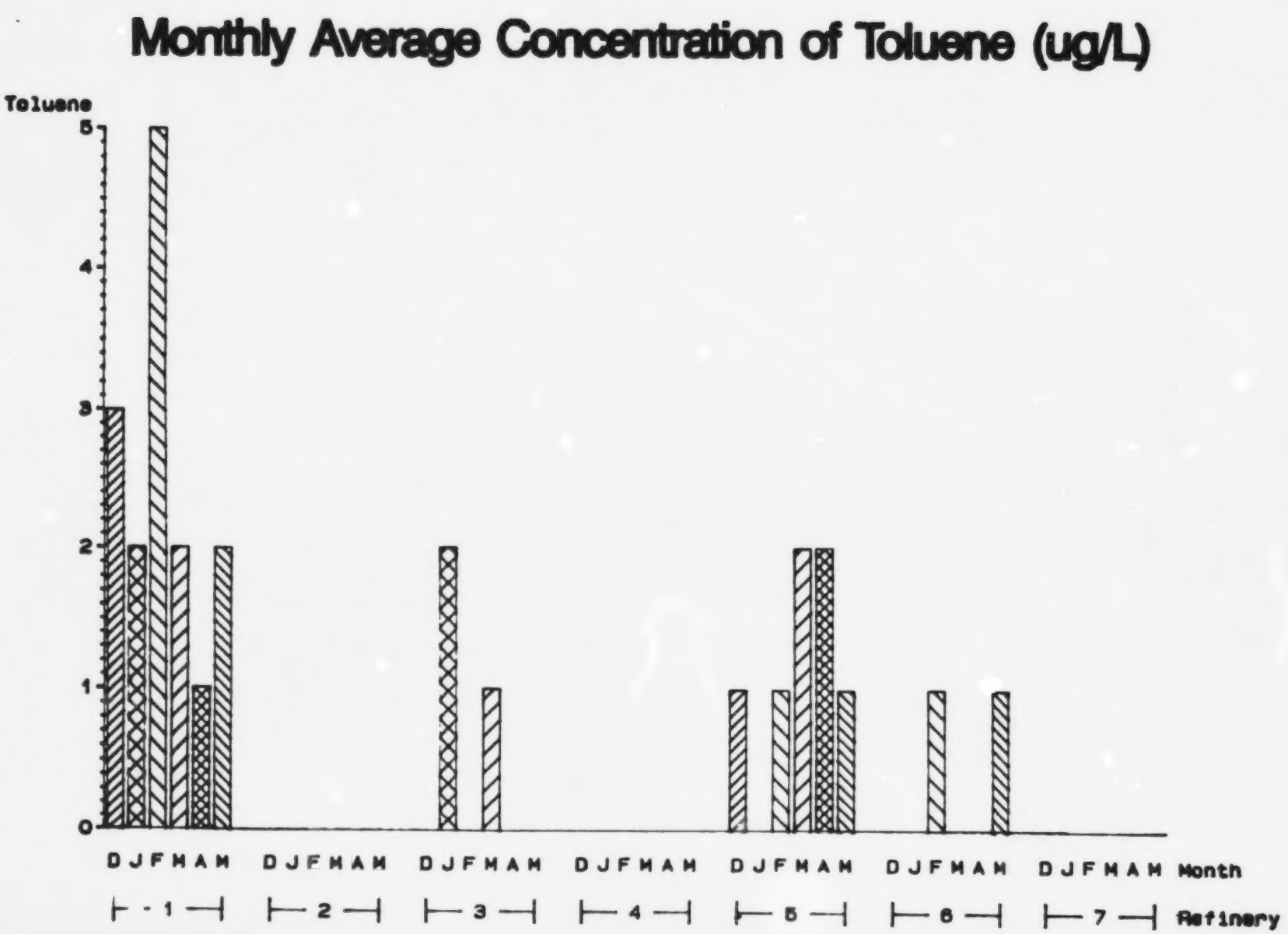

Monthly Average Concentration of Toluene (ug/L)
Toluene
5
4
3
2
1
0
D J F M A M
Month
1
2
3
4
5
6
7
Refinery

FIGURE 1.7

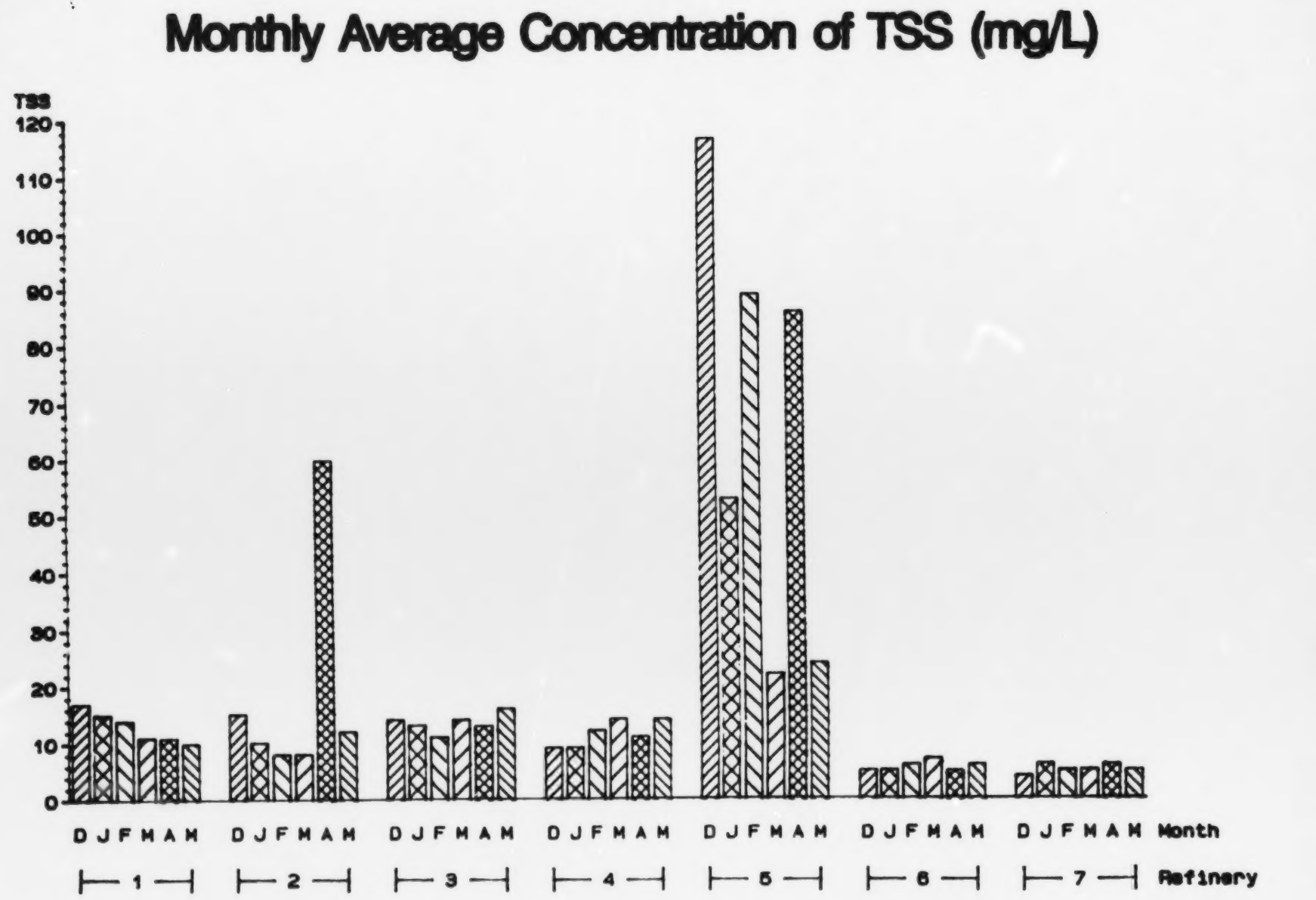

Monthly Average Concentration of TSS (mg/L)
TSS
120
110
100
90
80
70
60
50
40
30
20
10
0
D J F M A M
Month
1
2
3
4
5
6
7
Refinery

FIGURE 2.0

Monthly average flow (m3/day) for 7 refineries

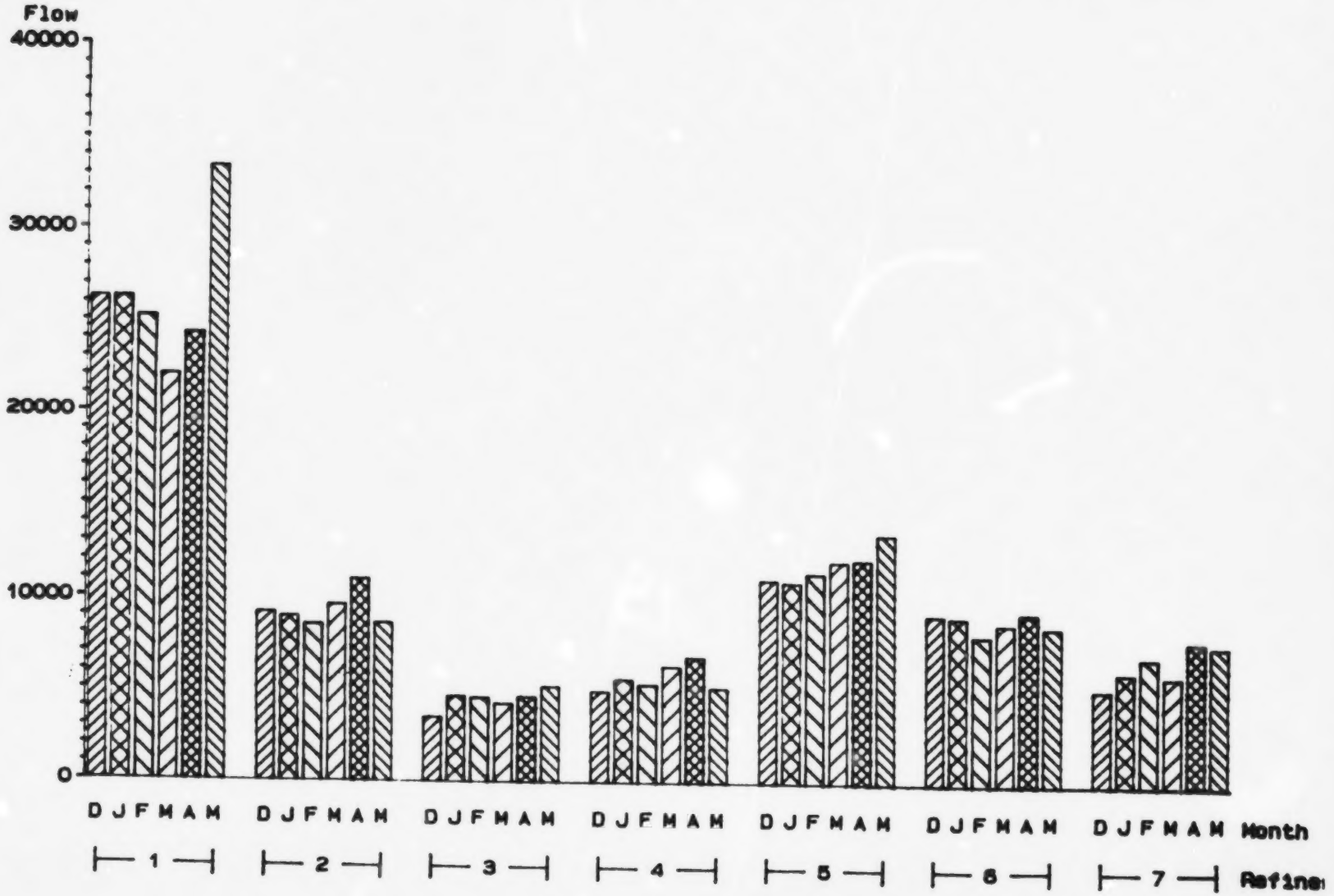


FIGURE 3.1

Monthly Average Daily Loading of Benzene (kg/day)

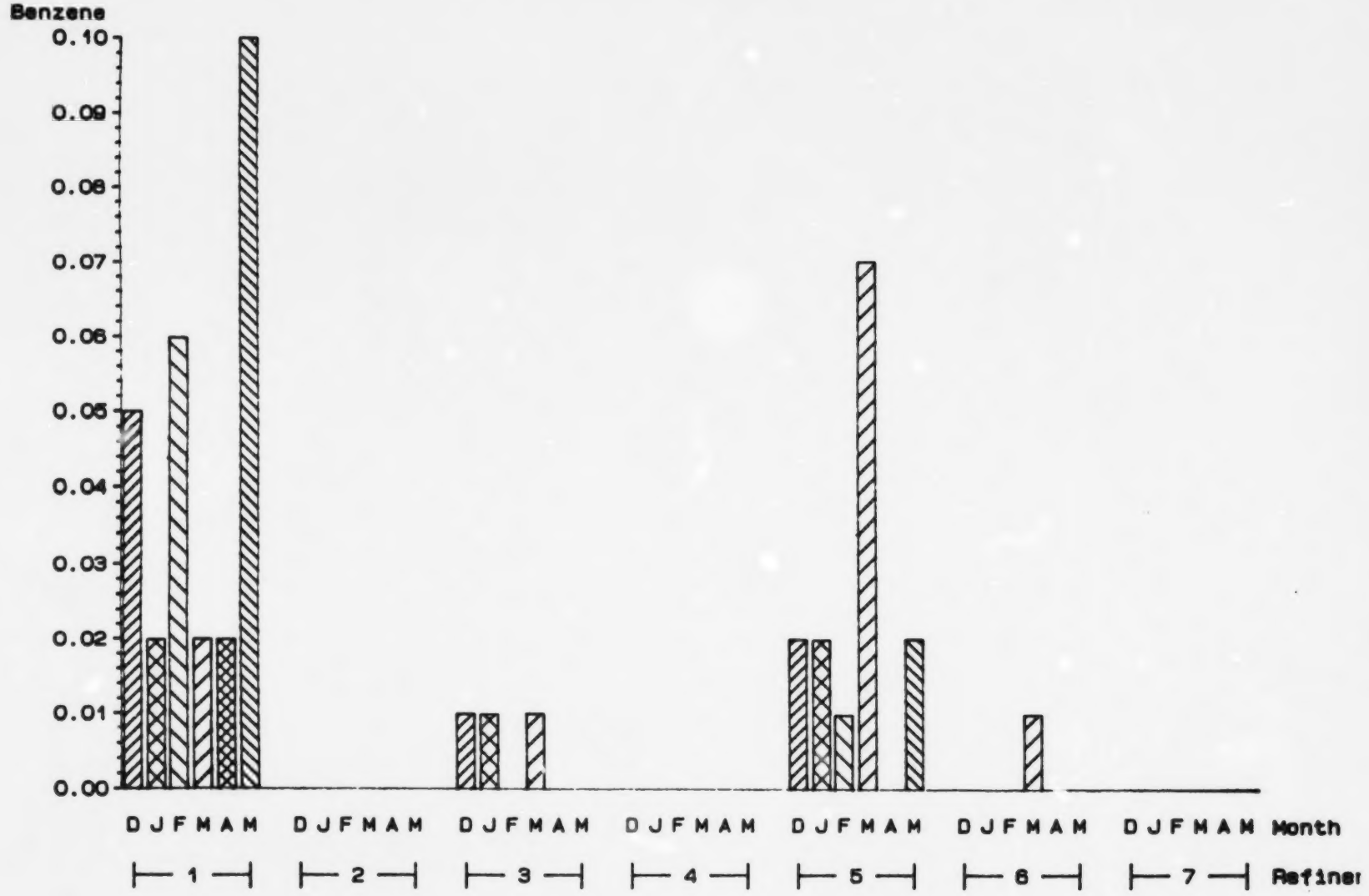

Benzene
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
D J F M A M D J F M A M D J F M A M D J F M A M D J F M A M D J F M A M D J F M A M Month
1 2 3 4 5 6 7 Refiner

FIGURE 3.2

Monthly Average Daily Loading of Chromium (kg/day)

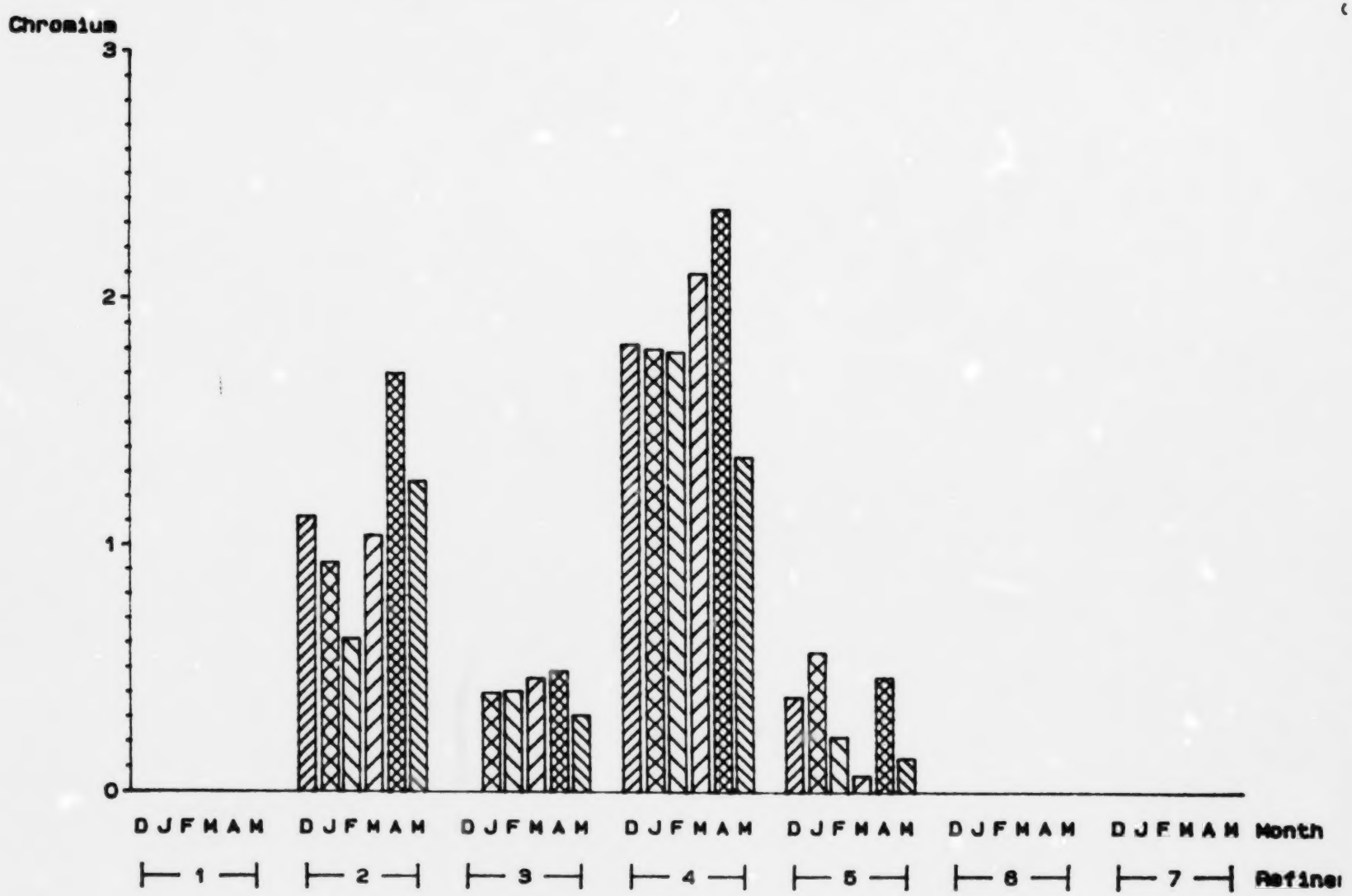


FIGURE 3.3

Monthly Average Daily Loading of Oil & Grease (kg/day)

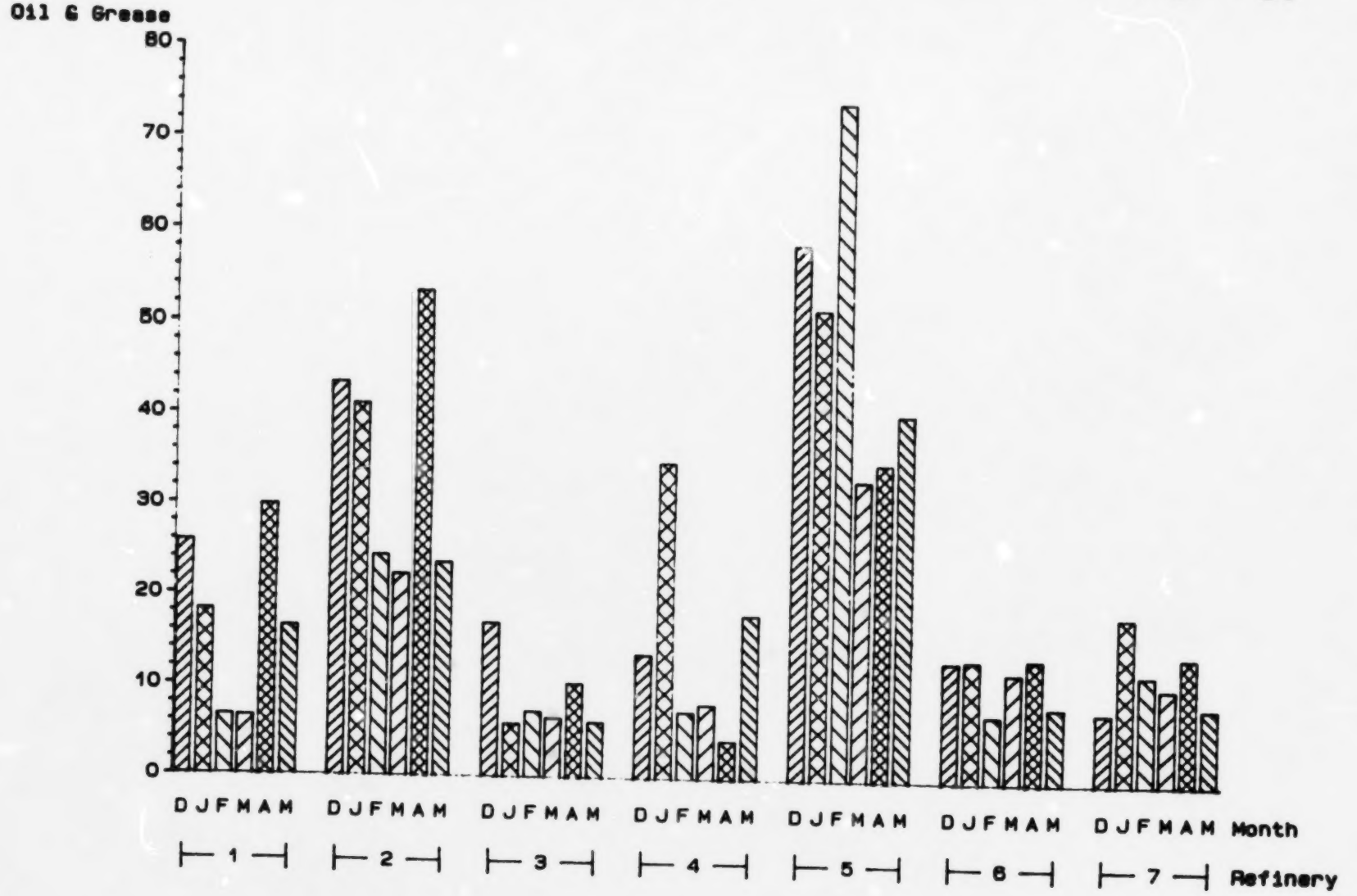


FIGURE 3.4

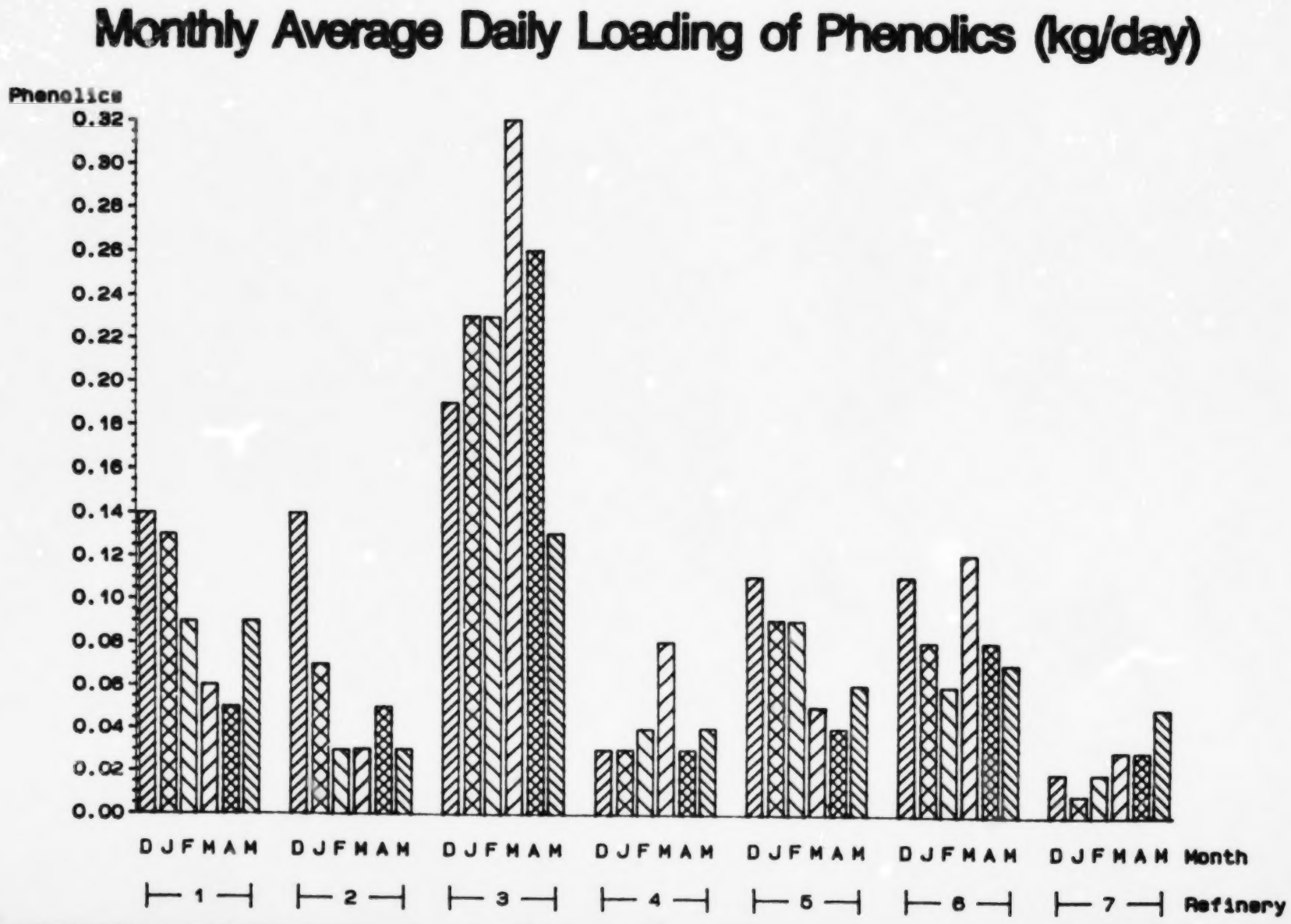

Monthly Average Daily Loading of Phenolics (kg/day)
Phenolics
0.32
0.30
0.28
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
D J F M A M
Month
1
2
3
4
5
6
7
Refinery

FIGURE 3.5

Monthly Average Daily Loading of Sulphide (kg/day)

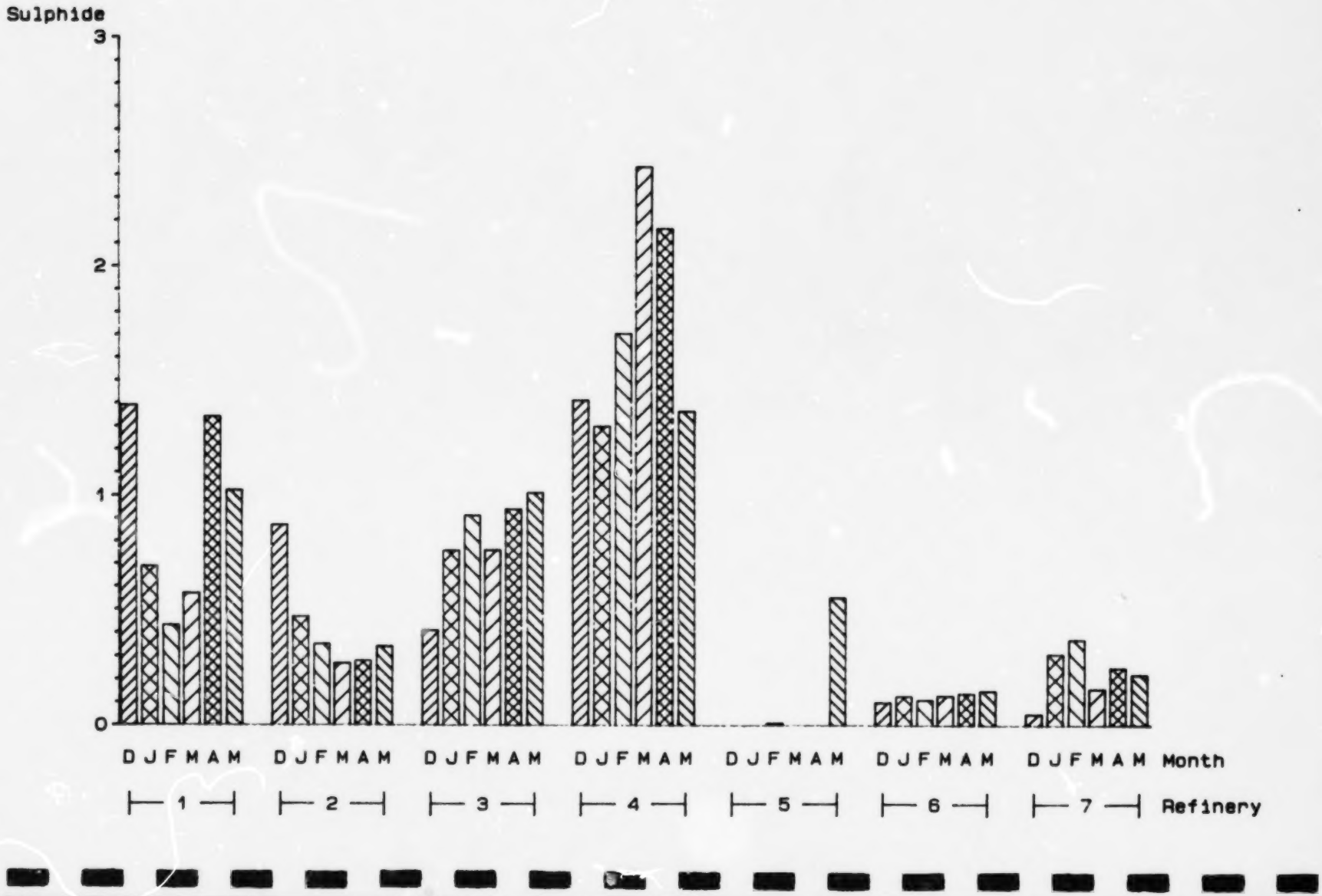


FIGURE 3.6

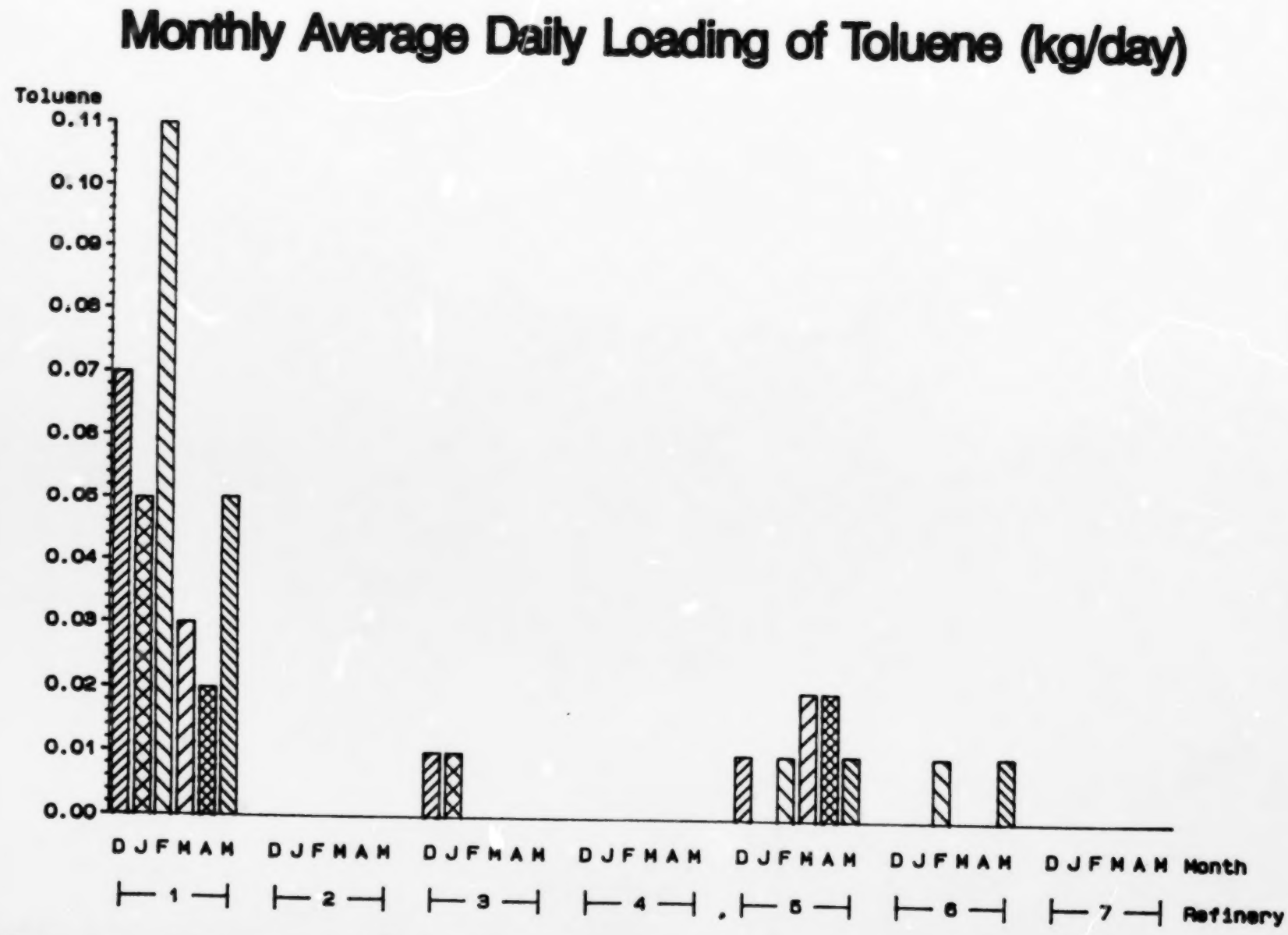
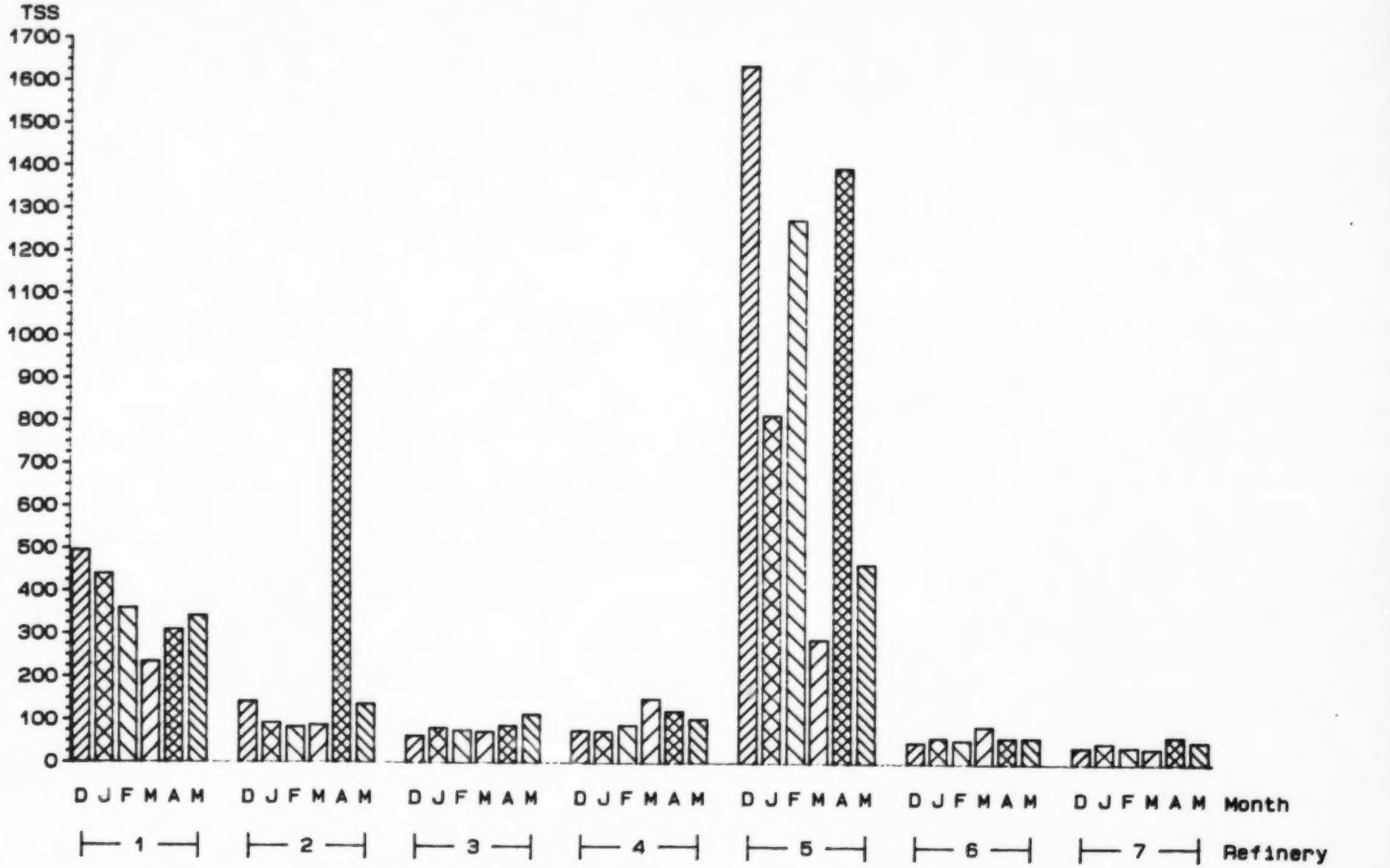

Monthly Average Daily Loading of Toluene (kg/day)
Toluene
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
D J F M A M
Month
1
2
3
4
5
6
7
Refinery

FIGURE 3.7

Monthly Average Daily Loading of TSS (kg/day)



12.2 REMARK CODES

Code	Description
?	Late data : data yet available : see text
!	No data will be reported: see textual report
!IN	No data: insufficient volume due to inspection
!NM	No effluent - no sample available
<	Actual amount less than reported
<DL	Reported value = MDL :measured amt. < MDL (non-zero)
<T	A measurable trace amount: interpret with caution
<TE	A measurable trace after extra diln/concn: caution
<W	No measurable response (zero): < reported value
<WE	No measurable response (diln/concn): < rept'd value
>	Actual amount probably greater than reported
A	Approximate value
AIS	Approximate value: insufficient sample
AR	Attached report
I	Interference suspected
IB	Interference: background
IC	Interference: colour
IM	Interference: Sample Matrix
MP	Multiphase sample: Result may be suspect
O	Old: sample exceeds maximum storage time
SD	Sample duplicates differ in appearance
SID	Sample identification questionable
SIP	Sample improperly preserved
UCR	Data unreliable: could not confirm by reanalysis
UNF	Data unreliable: container not filled to top
UQC	Data unreliable: possible lab QC problem(s)
USD	Data unreliable: Sample decomposition noted
P16	PCB resembled AROCLOR 1016
P20	PCB resembled mix of AROCLOR 1242 and 1260
P21	PCB resembled AROCLOR 1221
P24	PCB resembled mix of AROCLOR 1242 and 1254
P28	PCB resembled mix of AROCLOR 1242 and 1248
P32	PCB resembled AROCLOR 1232
P40	PCB resembled mix of AROCLOR 1254 and 1260
P42	PCB resembled AROCLOR 1242
P48	PCB resembled AROCLOR 1248
P54	PCB resembled AROCLOR 1254
P60	PCB resembled AROCLOR 1260
P80	PCB resembled mix of AROCLOR 1248 and 1260
P84	PCB resembled mix of AROCLOR 1248 and 1254
PS1	PCB resembled mix of AROCLOR 1248, 1254 and 1260
PS2	PCB resembled mix of AROCLOR 1242, 1254 and 1260

APPENDIX B

KEY TO THE REFINERY NUMBERS USED IN TABLES AND FIGURES:

Refinery 1 =	Esso Petroleum Canada (Sarnia)
Refinery 2 =	Petro-Canada Inc, Lake Ontario Refinery - Mississauga Plant
Refinery 3 =	Petro-Canada Inc, Lake Ontario Refinery - Oakville Plant
Refinery 4 =	Petrosar Limited (Sarnia)
Refinery 5 =	Shell Canada Products Limited (Sarnia)
Refinery 6 =	Suncor Inc. (Sarnia)
Refinery 7 =	McColl-Frontenac Inc. (Nanticoke) (previously Texaco Canada Inc.)